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Title
DC Power Distribution in Commercial Buildings

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**DC Power Distribution in Commercial Buildings**

### Why DC?
- **Energy Simulation**
  - Develop detailed converter loss models to help compare AC and DC.
  - Results determined from market cost data, grid tariffs, and Monte-Carlo analysis.
  - First cost is higher for DC.
  - Given the enormous efficiency savings, the payback period is less than a year.
  - End-use costs, installation costs, and other soft costs are not considered.

- **Techno-Economic Analysis**
  - Determine first cost difference through product data and estimated quantity.
  - Determine operating cost from the energy simulation and CA electricity tariffs.
  - Estimate economic benefits of DC distribution with life cycle cost (LCC) and payback period (PPB).

- **Experimental Load Modification**
  - Modify common AC plug loads for a DC input.
  - Measure efficiency savings with DC.
  - Determine how each type of load should be modified to benefit most from DC.

### Potential Benefits
- Simpler power electronics: better cost and reliability.
- Reliable microgrid islanding through power electronics allows for low-cost disaster resiliency.
- Improved power quality.
- Combined data and power allows for communications.

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### Technology and Market Trends
- DC-based distributed generation such as photovoltaic and wind.
- On-site DC electrical storage.
- The most efficient types of loads are natively-DC (LEDs, electronics, EV charging, induction stoves, and variable speed motors in HVAC and water heating).
- Power electronics.
- DC Power Standards: USB, Ethernet.
- Communications.

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### Analysis Approach

**AC vs. DC**

Energy Loss for Medium-Size Commercial ZNE Building

- **Energy Simulation**
  - 12% baseline efficiency savings with DC.
  - More savings with high solar and battery capacity.
  - AC building loss is dominated by the poor efficiency of load packaged rectifiers.
  - DC building loss dominated by the grid-tie inverter.

- **Techno-Economic Analysis**
  - Results determined from market cost data, grid tariffs, and Monte-Carlo analysis.
  - First cost is higher for DC.
  - Given the enormous efficiency savings, the payback period is less than a year.
  - End-use costs, installation costs, and other soft costs are not considered.

- **Experimental Load Modification**
  - Modified AC loads to take a DC input.
  - Demonstrated savings with DC input.

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### Results

- **Energy Loss Chart**
  - Grid-Tie Inverter
  - Battery Converter
  - Solar Converter
  - Load Converter
  - Wiring
  - Battery Chemistry

- **Payback Calculation**
  - Payback = \( \frac{\text{First Cost of AC System} - \text{First Cost of DC System}}{(1 + \text{Discount Rate})^n} \)

- **Table: Average LCC Savings**

### Future Research
- Develop detailed converter loss models to help compare AC and DC.
- Develop a DC Design Tool to help building designers compare.
- Field test upcoming and developed DC buildings.

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